PATENT SPECIFICATION

954,348

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements relating to the manufacture of Extrusion Dies having Internal Helical Grooves

We, FAIREY ENGINEERING LIMITED, a Company registered under the Laws of Great Britain, of Cranford Lane, Heston, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of metal extrusion dies of the type having an internal cylindrical surface formed with a deep, narrow helical groove, and to the use of such a die in the extrusion of helically-finned tubing.

The formation in an internal cylindrical surface of a narrow helical groove, which may be many times as deep radially as it is wide, is extremely difficult by conventional machining processes involving the use of a cutting or grinding tool, because of the interference between the tool and the curved walls of the newly-formed groove in which it is traversed.

According to the present invention a method of forming a helical groove in an internal cylindrical surface of a metal extrusion die comprises electrically disintegrating and removing the metal of the groove by an electro-erosion process, employing as the co-operating electrode in this process a conductor formed with an external helical fin.

The known electro-erosion processes are of four main types, namely (a) the electrolytic removal of metal from the workpiece, in which a direct current is passed through the workpiece and through a co-operating electrode whilst both are submerged in a conducting fluid, usually a solution of metallic salt or weak acid, and water, a small fluid-filled gap being maintained between the electrode and the workpiece as the electrode is progressively advanced;

(b) electro-arcing, in which an arc-discharge is maintained between a co-operating electrode and the workpiece by a supply of arcing current, either direct, continuous or pulsing, the gap between the electrode and the workpiece being maintained substantially constant as the electrode is advanced and the electrode and work being submerged in dielectric fluid which is used to wash away the disintegrated particles of metal from the work;

(c) electro-sparking, which is basically the same as electro-arcing except that a succession of electric spark discharges is produced across the dielectric-fluid-filled spark gap between the electrode and the workpiece, the electric charge being obtained from capacitors; each spark striking the workpiece dislodges a small particle of metal from it, and the repeated spark bombardment thus erodes the metal of the workpiece; and

(d) electro-abrasion, in which the co-operating electrode is vibrated electrically at a frequency of 28,000—30,000 cycles per minute, and a fine abrasive mixture is suspended in the fluid which occupies the small gap between the electrode and the workpiece; the effect of the rapid vibrations acting through the abrasive particles on the workpiece is to produce a form of high-frequency hammering which has an erosive effect on the workpiece causing its local disintegration.

The electro-sparking process referred to at (c) is the form of electro-erosion preferred for use in the present invention.

The invention according to another of its aspects comprises a method of manufacturing a bar or tube workpiece of extrudible material having an external upstanding helical fin, by directly extruding the workpiece through a metal extrusion die having an internal cylindrical surface formed by an electro-erosion process with a helical groove of corresponding pitch and dimensions.

The invention may be carried into practice in various ways but one specific embodiment will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an elec-

trode in carrying out the invention, and

Figure 2 is a view of the extrusion die formed.

A metal extrusion die 10, used for the direct extrusion of helically-finned tubing is formed with internal helical grooves 11 by the electro-spark process of electro-erosion. Thus the die, formed with its basic internal cylindrical bore, is submerged in a bath of dielectric liquid and is connected to the negative terminal of an electric storage circuit so as to constitute the cathode, whilst a suitably shaped and dimensioned metal electrode generally indicated at 12 is connected to the positive terminal of the circuit so as to constitute the anode, and is supported by a suitable adjustable clamp, not shown. The anode comprises a length of metal rod 13 which is formed with external helical fins generally indicated at 14 corresponding in pitch to that of the required helical grooves, but slightly smaller in radial fin height and in fin thickness than the required radial depth and width of the grooves. The basic diameter of the rod is slightly smaller than the diameter of the bore in the die, and it is provided at its leading end 15 with lead-in helical fin portions 16 whose radial height increases progressively from zero at the tip of the rod to the full fin height.

The electrode 12, which is helically finned, is made free to rotate in the machine spindle but is restrained from turning freely by a pair of guide pins 17, so that when it is advanced coaxially into the bore in the submerged die each helical fin advances progressively along a helical path coincident with its own length.

The electric storage circuit includes a source of electric power and a battery of capacitors, whereby each time the spark gap between the electrode and the workpiece is reduced below the dielectric breakdown distance the capacitor will discharge and a spark will jump across the spark gap between the electrode and the workpiece, and the spark discharge will cause a particle of the material of the workpiece to be dislodged at the point of impact of the spark. After each discharge the capacitors will recharge, at a rate which may be controlled, in readiness for the next spark discharge. The particles of material dislodged by the sparks are washed away by the dielectric liquid filling the gap between the electrode and workpiece. A continuous flow of liquid may be pumped through this gap, for example through a longitudinal bore (not shown) formed centrally in the electrode rod.

Thus in operation the electrode rod is advanced slowly and progressively downwardly into the bore of the die submerged in the bath, whilst liquid dielectric is pumped through the central bore in the workpiece so as to enter the bore in the die and emerge through the gap between the die and the electrode. The spark discharge occurs repeatedly between the lead-in portion 16 of the helical fin and the bore of the die, causing the local disintegration and erosion of the material of the die at the points of impact of the spark which will discharge itself across the spark gap at the point where it is narrowest. Thus as the electrode is slowly advanced whilst being turned by the pin and groove mechanism, the zone of disintegration will also advance progressively, producing an erodod groove corresponding to and surrounding the fin on the electrode. The rate of advance of the electrode is so controlled as to keep the gap between it and the workpiece substantially constant in the sparking region.

The size of each eroded groove formed in the bore of the die will thus be greater in radial depth than that of the fin on the electrode by an amount slightly greater than the mean width of the spark gap, and the width of each groove will be greater than the fin thickness by slightly more than twice that amount.

The grooved die formed thus by spark-erosion may be employed in an extrusion press for the direct extrusion, from billets, of metal rod or tube formed with external helical fins of pitch and dimensions corresponding to those of the helical grooves. Thus a tube having multi-start helical fins can be extruded through a die whose bore is formed with a corresponding multi-start helical groove.

WHAT WE CLAIM IS:—

1. A method of forming a helical groove in an internal cylindrical surface of a metal extrusion die, which comprises electrically disintegrating and removing the metal of the groove by an electro-erosion process employing as the co-operating electrode a conductor formed with an external helical fin.

2. A method as claimed in Claim 1 using the electro-sparking method of electro-erosion, in which a succession of electric spark discharges is produced across a dielectric fluid filling the gap between the electrode and the workpiece, each spark striking the workpiece and dislodging a small particle of metal from it, repeated sparking producing erosion.

3. A method as claimed in Claim 1 or Claim 2 in which a rod shaped anode is provided with helical grooves having zero height at the lead in portion of the rod and increasing progressively to full height.

4. A method as claimed in Claim 3 in which the helically finned electrode is mounted so as to be free to rotate but is restrained from turning freely by one or more guide fins engaging the fin so that when it is advanced coaxially into the bore in the submerged die the helical fin advances progressively along a helical path coincident with its own length.

5. A method as claimed in any of Claims 2 to 4 in which the dielectric fluid filling the gap between the electrodes is pumped through a central bore in the workpiece so as to enter

the bore in the die and emerge through the gap between the die and the electrode.

6. A method of manufacturing a bar or tube workpiece of extrudible material having an external upstanding helical fin in which the workpiece is extruded directly through a metal extrusion die having an internal cylindrical surface with a helical groove of corresponding pitch and dimensions formed by an electro-erosion process.

7. A method of forming a helical groove in an internal cylindrical surface of a metal extrusion die as specifically described herein with reference to the accompanying drawings.

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Agents for the Applicants.

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954348 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

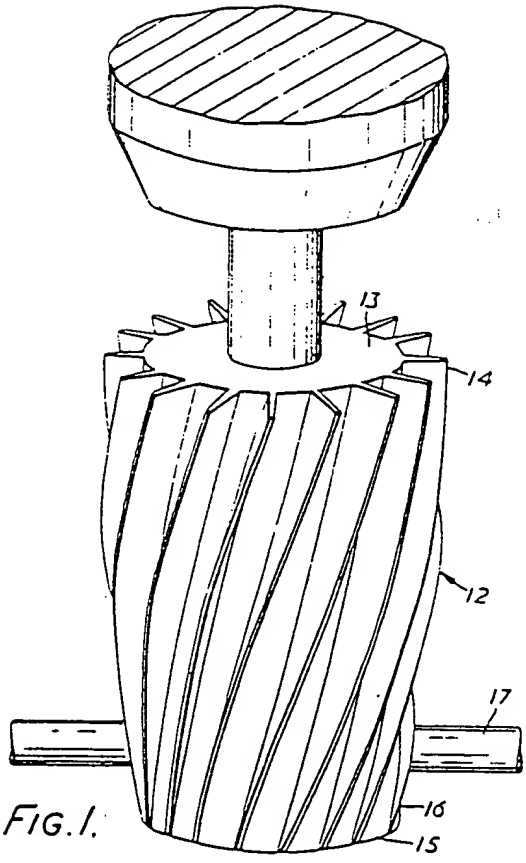

FIG. 1.

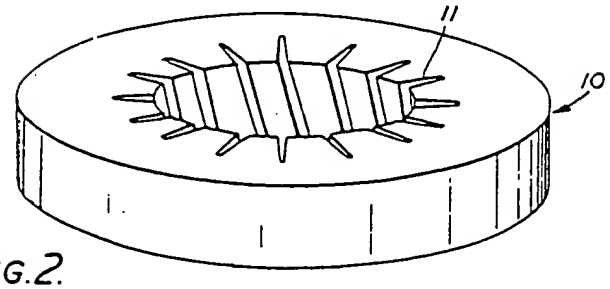

FIG. 2.